Regular physical activity linked to better organized preteen brains

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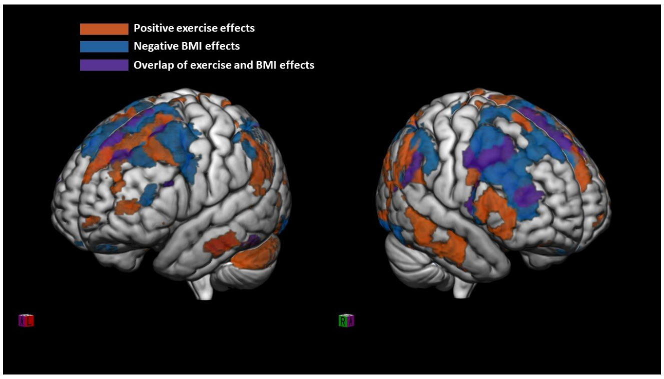

The images show positive effects of physical activity (in orange) and negative effects of BMI (in blue) on local brain networks. Areas where the effects of exercise and BMI overlap are shown in purple. Credit: Skylar Brooks, Computational Neuroscience Laboratory, Boston Children's Hospital

Regular physical activity has positive effects on children's developing brain circuits, finds a Boston Children's Hospital study using neuroimaging data from nearly 6,000 early adolescents. Physical activity of any kind was associated with more efficiently organized, flexible, and robust brain networks, the researchers found. The more physical activity, the more "fit" the brain.

Findings were published in *Cerebral Cortex* on May 14.

"It didn't matter what kind of physical activity children were involved in—it only mattered that they were active," says Caterina Stamoulis, Ph.D., principal investigator on the study and director of the Computational Neuroscience Laboratory at Boston Children's. "Being active multiple times per week for at least 60 minutes had a widespread positive effect on brain circuitry."

Specifically, Stamoulis and her trainees, Skylar Brooks and Sean Parks, found positive effects on circuits in multiple brain areas. These circuits play a fundamental role in cognitive function and support attention, sensory processing, motor function, memory, decision-making, and executive control. Regular physical activity also partially offset the effects of unhealthy body mass index (BMI), which was associated with detrimental effects on the same brain circuitry.

Harnessing big data

With support from the National Science Foundation's Harnessing the Data Revolution and BRAIN Initiative, the researchers tapped data from the long-term, NIH-sponsored Adolescent Brain Cognitive Development (ABCD) study. They analyzed functional magnetic resonance imaging (fMRI) data from 5,955 9- and 10-year-olds and crunched these data against data on physical activity and BMI, using advanced computational techniques developed in collaboration with the Harvard Medical School High Performance Computing Cluster.

"Early adolescence is a very important time in brain development," notes Stamoulis. "It's associated with a lot of changes in the brain's functional circuits, particularly those supporting higher-level processes like decision-making and executive control. Abnormal changes in these areas can lead to risk behaviors and deficits in cognitive function that can follow people throughout their lifetime."

Gauging functional brain organization

The functional MRI data were captured in the resting state, when the children were not performing any explicit cognitive task. This allows analysis of the "connectome"—the architecture of brain connections that determines how efficiently the brain functions and how readily it can adapt to changes in the environment, independently of specific tasks.

The team adjusted the data for age, gestational age at birth, puberty status, sex, race, and family income. Physical activity and sports involvement measures were based on youth and parent surveys collected by the ABCD study.

The analysis found that physical activity was associated with positive brain-wide network properties reflecting the connectome's efficiency, robustness, and clustering into communities of brain regions. These same properties were detrimentally affected by high BMI. Physical activity also had a positive effect on local organization of the brain; unhealthy BMI had adverse impacts in some of the same areas.

"Based on our results, we think physical activity affects brain organization directly, but also indirectly by reducing BMI, therefore mitigating its negative effects," Stamoulis says.

Optimal functional brain structure consists of small regions or "nodes" that are well connected internally and send information to other parts of the brain through strong, but relatively few, long-range connections, Stamoulis explains.

"This organization optimizes the efficiency of information processing and transmission, which is still developing in adolescence and can be altered by a number of risk factors," she says. "Our results suggest that physical activity has a protective effect on this optimization process across brain regions."

Provided by Children's Hospital Boston
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